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THE BEARING OF THE RESULTS OF MENTAL TESTS ON THE MENTAL DEVELOPMENT OF THE CHILD

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IT is surprising to note how little the results of mental tests have been used as a basis for a critique of our views of the mental development of the child. These views have become traditional and are based upon data which were gathered before the present day era of mental testing had opened. The scientific facts upon which our current conceptions are based are exceedingly slender in comparison with the rich material which now awaits our formulation. It is probably no exaggeration to say that there is now available for interpretation ten times as much material bearing upon the age progress of the child in intellectual functions as was available ten years ago. I have attempted in this paper to make a survey of the most significant of this material and to examine critically our conceptions of intellectual growth in the light of it. In the examination of the data we should consider such questions as the following:

1. Age progress in particular intellectual functions.
2. Age progress in more general or composite intellectual functions.
3. The correspondence between this age progress and physical growth and development.
4. The relationship between the progress of the average or median child and the progress of those who are above or below the median.
5. The relation between the facts already mentioned and current methods of expressing the relationship between the individual of inferior or superior ability and the individual of median ability. This question deals particularly with the now commonly used I. Q. (Intelligence Quotient).
6. The nature of the differences in the intellectual capacity of children at different ages. This topic raises the question whether the differences are chiefly in amount of ability or whether there are also differences in kind. In other words, the problem is whether the child simply increases, through development, the powers which he already possesses, or whether he acquires new powers as he grows older. This topic is not included in the present discussion.
7. Finally, we may consider some of the practical bearings of the facts upon such problems as the grouping of the children in school.

AGE PROGRESS IN PARTICULAR INTELLECTUAL FUNCTIONS

We may introduce the topic of age development by examining some of the chief data which were gathered by earlier students of this problem. About 1900 Smedley made tests of memory on a large number of school children. He presented the results of this test in the form of a curve which represents the achievement of the child at each age from 7½ to 19½. The type of memory which was tested was a very simple one, namely memory span for digits. It consisted in requiring the child to reproduce a series of numbers which were spoken to him or presented to him visually. The curves for visual and auditory memory are shown in Fig. 1. From these curves the conclusion has been drawn that auditory memory ceases to improve between the ages of 13 and 14 and the visual memory between the ages of 14 and 15. In other words, memory develops rapidly until early adolescence and then practically ceases to improve. It is rather astonishing that so far-reaching a conclusion should have been drawn from an experiment with only one type of memory and that a very simple one. We shall see from the examination of the other progress curves that the age at which improvement ceases depends in a large measure upon the difficulty and complexity of the test which is used. It is quite unjustified to conclude that memory for narrative, or for expository prose, or for poetry follows the same course of development as memory for digits.

The difference in the age at which progress slows down or ceases is shown in the three examples from a still earlier investigator, Gilbert, whose report was published in 1895. A careful examination of Gilbert's results indicates that the age at which one function matures may be very different from the age at which another reaches its climax. Chart No. 2 shows the progress in discriminating differences in color. We see that this ability ceases to develop rapidly at 10 years. The break in development comes in the middle of the period of later childhood, between second dentition and adolescence. In the third chart is shown progress in the discrimination between weights, which Gilbert calls muscle sense. The development in this capacity apparently ceases at the age of 13, in early adolescence. Development in rate of movement, as tested by rapidity of tapping, (Chart 4), shows a break at the age of 13, but unlike the muscle sense continues its development after this break up to the age of 17. In another investigation of progress in tapping there is no such clear break at 13 as was found by Gilbert. Chart 5 from Bickersteth shows fairly continuous progress up to the age of 14½. We have thus already found a considerable variety in the time of maturing of various functions.

The following charts will illustrate further this variety in the form of progress of relatively simple functions. Chart 6 represents progress in a test which consisted in marking with a pencil a succession of dots. The speed of the dots was progressively faster so that the test passed from easier to more difficult stages. The progress in this ability shows no radical retardation from the age of 5½ to 15½, though there are minor retardations at 10½ and 13½. In general, however, the curve of the line of advancement is straight up to the age of 15½.

The next chart shows progress curves in three examples of another

Fig. 1. Age progress curves in memory span for digits presented visually and orally (from Smedley)

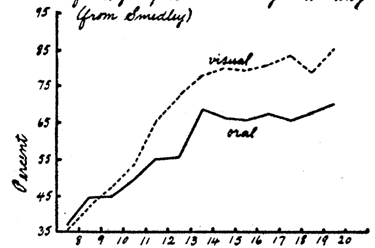


Fig. 2. Age progress curves in discrimination of color (from Gilbert)

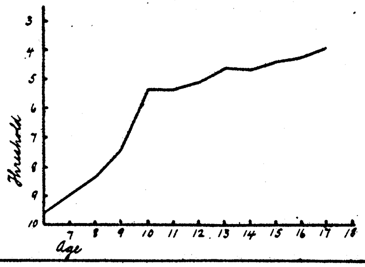


Fig. 3. Age progress curves in weight discrimination (from Gilbert)

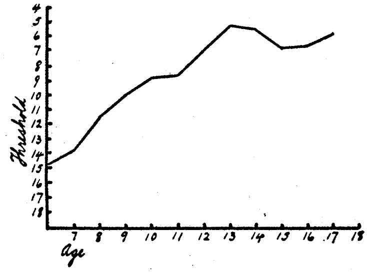


Fig. 4. Age progress curves in rate of tapping (from Gilbert)

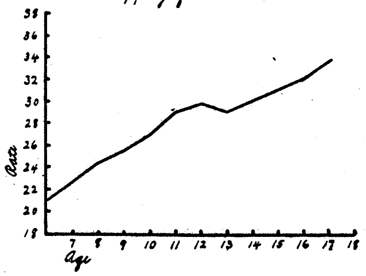


Fig. 5. Age progress curves of girls in rate of tapping (Bickersteth)

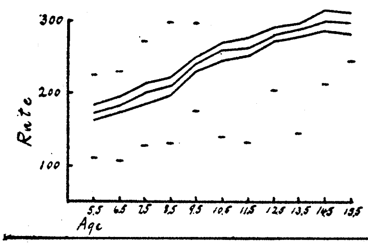


Fig. 6. Age progress curves of girls in marking dots on moving paper (Bickersteth)

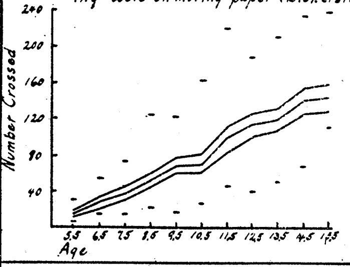


Fig 7. Age progress curves of girls in finding and crossing letters and numbers in sequence (Bickersteth)

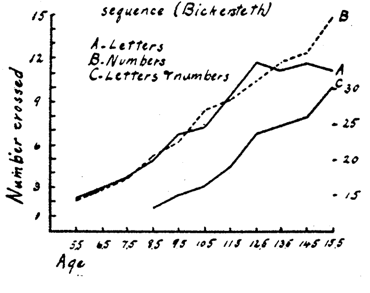
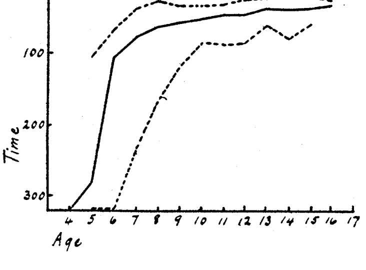


Fig. 8. Age progress curve in a simple construction puzzle (Pintner)



test. The test is given by presenting to the child a card upon which are arranged letters of the alphabet and numbers in irregular order. The problem is to cross out the letters of the alphabet or numbers in order. In the third form letters and numbers are mixed. We see that in two of the tests, namely crossing numbers and crossing numbers and letters combined, there is no let up in progress up to the age of 15½. There is a slight break at 13½ in the combination test but none in the number test. In the alphabet test, however, progress ceases at the age of 12½. There thus appear radically different forms of progress in the tests which superficially seem to be practically identical. It is impossible to predict where a break in progress will come on the basis of a knowledge of the general character of the test. It is equally incorrect to say that the break of progress in different tests will come at any common age.

A similiar variety in the ages at which ability culminates is seen in three examples from the performance tests given by Pintner and Patterson. The first of these is the so-called triangle test. It consists in fitting triangular pieces into an opening. It is an example of the form board test. The culmination in this ability comes at the age of 6, with very slight progress after this age. There is enormous progress between the ages of 5 and 6 (chart 8). Another form board test used by Pintner, on the other hand, shows this rapid progress at a different age. It is the so-called picture profile test in which the task is to place a number of blocks so as to form the outline of a face. The rapid progress in this test comes between the ages of 9 and 11, and the culmination is practically reached at the age of 11 (chart 9). Chart 10 shows somewhat more gradual advance with age, in which the most rapid progress comes between 5 and 9, slower progress between 9 and 12, and practically no progress after this age. This is the so-called picture completion test. A series of parts of a picture pasted on a board are cut out of a picture and mixed with a number of blocks on which other pictures are pasted. The task is to select the proper block from the collection and insert it in the proper opening in the large picture. The range of chances of correct moves is large and the scoring system is worked out in considerable detail. Progress is therefore represented in a more refined fashion than in some of the preceeding tests.

The examples thus far have been drawn from general mental tests, which measure somewhat abstract abilities. The same differences in age of maturing of different functions can be illustrated, however, from tests in school subjects. On chart 11 are shown three curves of advancement in reading from Gray's investigation. The continuous line shows advance in the rate of oral reading, the broken line in the rate of silent reading and the dotted line in quality of silent reading. It will be

Fig. 9. Age progress curve in a simple construction puzzle (Pintner)

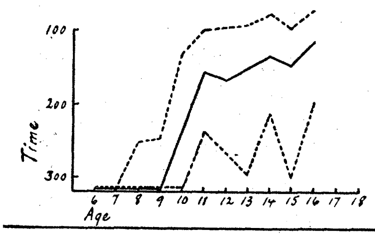


Fig. 10. Age progress curve in a picture completion puzzle (Pintner)

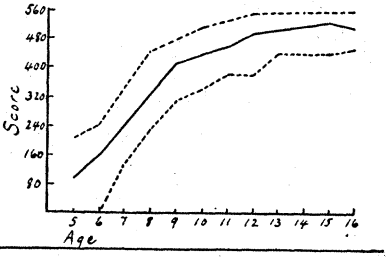


Fig. 11. Grade progress curves in reading (Gray)

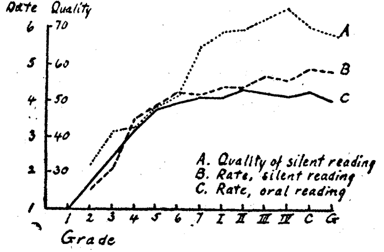


Fig. 12. Average age in the school grades

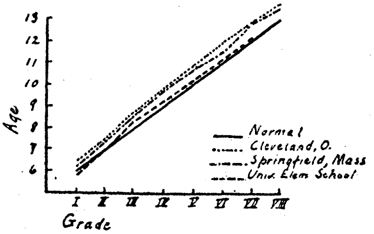


Fig. 13a. Percentage of children testing below age who reach or exceed those of same mental age who test at age in nine single tests (Evans and Castle)

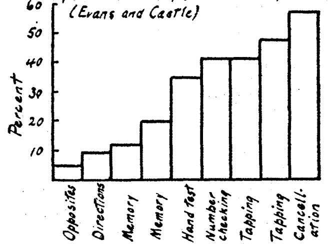


Fig. 13b. Diagram illustrating the relative effect of age on the scores of various tests shown in Fig. 13a, and in the Yerkes Point Scale, there used as basis for mental age

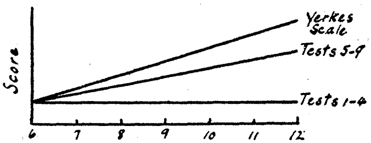


Fig. 14. Grade progress curves in simple multiplication and division (Judd)

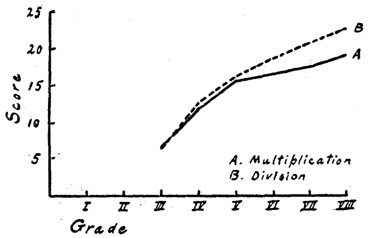
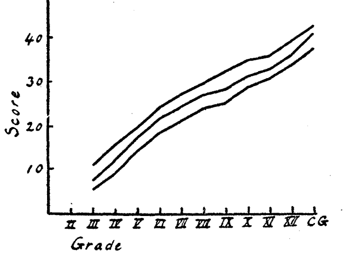


Fig. 15. Grade progress curves in sentence completion (Trabue)



seen that the progress in rate of silent and oral reading is relatively very similiar, although the rate of silent reading is above that of oral reading from the fourth grade on. The curve for quality of silent reading, however, takes a radically different course. There is marked and continuous progress up to and including the Senior year of the High School. It is probable that this progress would continue through the further two groups which were tested, namely college students and graduate students, if their attitude toward the test had been as natural as that of the younger pupils.

The question of technique in the interpretation of these tests arises from the fact that, unlike the preceeding tests, the results are grouped by school grades rather than by ages. If the pupils of successive grades were all of the same age, and if each grade represented an advancement of one year in age over the preceeding one, the curves would be based upon the same groupings. Neither of these conditions, however, obtains. The relation between age and grade may be illustrated by a chart showing the average age of pupils in successive school grades. On chart 12 is shown by the continuous line, the normal age for each school grade, assuming the pupils enter at six years and advance one grade each year. The next line above represents the average age for the successive school grades in the University Elementary School. It appears that in all grades except the first two the average age is somewhat above the normal. The other broken lines represent the same facts for Springfield, Mass., and for Cleveland, O. The average age in the public schools is considerably above that both of the normal and the University Elementary School for each grade.

Assuming that the results from school grades would be the same as results from age groups if the average age corresponded to the normal expectation, we may ask what effect this deviation of the actual from the expected may have upon age progress curves. In order to answer this question it is necessary to know whether the average score in a test would be raised or lowered by the fact that the average age of the grade is above normal. The question may seem at first sight ridiculous, but it ceases to be so when we consider that the pupils who are above the normal age in any particular grade are retarded because of backwardness in mental growth. Investigations have repeatedly shown that the younger pupils in the same grade may do better in certain tests than the older pupils in the same grade. In such a test, therefore, the excess in the average age of the pupils might be expected to lower the curve at the point at which it occurred. On the other hand, it may be true that in some tests the older pupils would do better than the younger pupils of the same grade. We might for convenience call this type of test a maturity test, and the type in which the younger pupils excel a brightness test.

Fig. 16. Grade progress curves for completion of sentences of varying difficulty (Trabue)

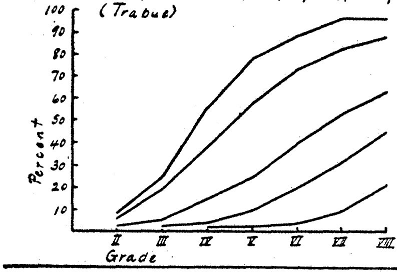


Fig. 17. Age progress curve in the Yerkes Point Scale

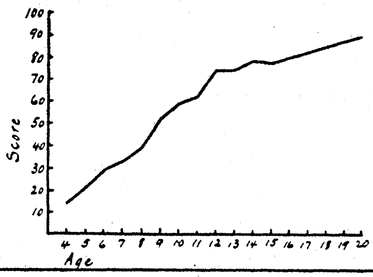


Fig. 18. Age progress curve in the Pressey Group Test

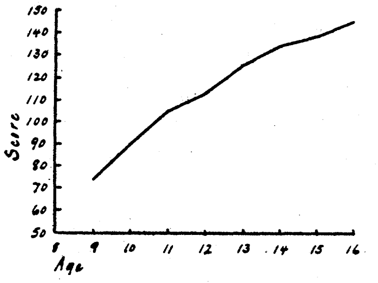


Fig. 19. Grade progress curves in Forms A and B of the Chicago Intelligence Test

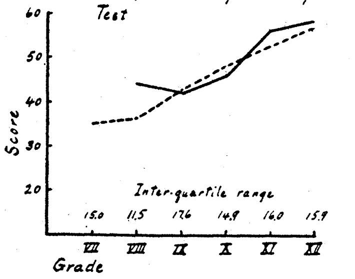


Fig. 20. Age progress curves in Haggerty's tests Delta 1 (A) and Delta 2 (B).

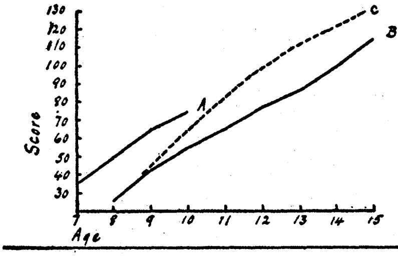


Fig. 21a. Hypothetical age progress curves in Intelligenoe (Woodrow)

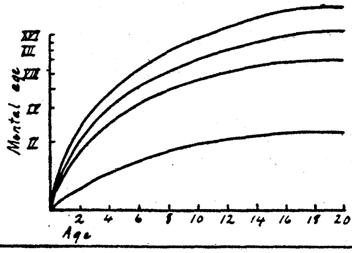


Fig. 21b. Hypothetical straight-line age progress curves

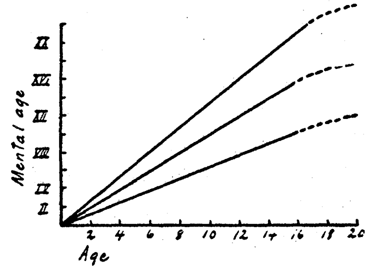
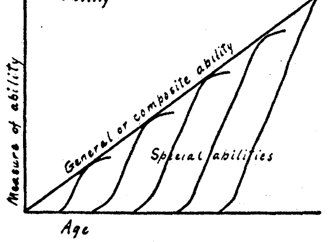


Fig. 22. Hypothetical relation between development in special and general ability



That there are such differences between tests is made clear by Chart 13a. In the upper part of the chart are represented the scores in a variety of tests given to a group of children. These children varied in chronological age, but were similiar in ability as measured by the Yerkes point scale. This group, homogeneous so far as their ability in this scale was concerned, were given nine tests. In order to compare the factors of brightness and of age in these nine tests the entire group of children was divided into two groups. The first consisted of all those whose mental age did not correspond to their chronological age. For the most part their ages were above the normal. In the other group the mental and the chronological ages correspond, that is, their mental advancement was what might be expected from their age. The relative standing of these two groups was thus compared in each of the nine tests. Each horizontal column represents one of the tests, the first column an opposite test, the second a directions test, the third a memory test, etc. The length of the column represents the percentage of the older children of the group who exceeded the median of the normal children. If the column reaches fifty per cent., as it does in the last two tests, it indicates that the two groups are equal. If the column is short it indicates that the older children are inferior to the younger ones. In the last five tests, which consisted in simple sensory and motor processes, the older children were nearly equal or fully equal to the younger ones, while in the first four they were markedly inferior. We may express these facts by saying that in some tests, physical maturity, as distinguished from brightness, is of little avail, whereas in others improvement accompanies to a much greater extent mere chronological age.

We may express the differences between these types of abilities by the figure chart 13b. The lines indicate the relative degree of advancement we may expect in a test from mere physical maturity. Thus we see that in the Yerkes scale and in tests 5 to 9 the factors of maturity and of brightness have about the same relative influence, while in tests 1 to 4 the factor of brightness outweighs that of maturity in comparison to both the Yerkes scale and tests 5 to 9.

To come back now to our interpretation of the grade progress curve, we may say that if the test in question depends largely upon physical maturity the curves which represent it will be higher in intermediate grades, and in some cases in the grammar grades, than would be the same age progress curve. If the test is one of brightness however, it is probable that the curves would either not be raised or would be slightly lowered by the excess age of children in these grades.

Since the above was originally written both an age and a grade progress curve in the same test have become available for the Haggerty test, Delta 2. These curves are shown in Fig. 20, B and C. The age progress curve is practically a straight line while the grade progress is more rapid up to Grade VI and then decreases. The form of the grade curve suggests that success in this test depends largely on maturity. From the third grade to the fifth the number of over age, dull, pupils increases, while the number of under age, bright pupils decreases. After the sixth grade the number of over age pupils decreases rapidly and the number of under age pupils nearly holds its own. There is one serious difficulty in the interpretation of these data, however. The superiority of the grade progress curve is much greater than can be accounted for by the preponderance of over age pupils in the grades and the assumption that the score depends chiefly on age. For example, the average age of eighth grade pupils in two cities, Cleveland and Springfield, Mass., is 13.66 years and 13.53 years respectively. The score for year 13.6 according to the age norms would be about 95, but the score for grade VIII is 120. Since the results come so far from fulfilling the legitimate expectations in this respect, then, we may well be hesitant in drawing the natural conclusion which is suggested above from the form of the curve, particularly since the younger children of a school grade have been shown repeatedly to make a higher score in tests of this sort than do older pupils. The question of the relation between age and grade progress curves must be left open to further investigation.

We may then use these grade progress curves to represent roughly progress with age but must bear in mind that they may be somewhat distorted. Another illustration from school subjects is given in chart 14 which represents grade progress in simple multiplication and division as measured in the Cleveland Survey. While there is continuous progress in division to the eighth grade, there is a marked break in progress in multiplication at the fifth grade. Thus in two of the operations in the same school subject we find the progress curves representing different periods of maturing.

AGE PROGRESS IN GENERAL OR COMPOSITE FUNCTIONS

Progress curves which have been shown up to this time represent development in fairly specific mental functions. We may compare with these a number of curves which represent somewhat more complex functions or composite functions. The first one, shown on chart 15, is not greatly different from those which we have already been shown. It represents progress in ability to complete mutilated sentences as taken from the study of Trabue. The sentences are so arranged as to advance from very easy to difficult. This makes possible a wide range of scores and gives an opportunity for pupils of little ability and also for pupils of much greater ability to be faithfully represented in the score. The progress curve on this test is accordingly very different from that which was obtained in most of the preceeding examples. It represents an almost uniform rate of progress from pupils in the second grade to college graduates. This means that the development in the ability which is required in this test is practically uniform. The facts here represented suggest very strongly the view that the form of progress in which there is rapid gain within a small range of ages, followed by little gain, is due to the fact that the test is of such a character as to measure only a given degree of difficulty, or given level of ability, in the function which is measured. It suggests that if a test were so designed as to give opportunity for all ranges of performance in a function, the curve would show more continuous and extended advance.

That this hypothesis is a reasonable one is indicated by the next chart, No. 16, in which curves for several individual sentences of the Trabue test are given separately. The upper curve obviously represents an easy sentence, since the ability to pass it develops early. The lower curves represent successively more difficult sentences. We have here then a succession of progress curves in the same function, which take radically different courses, and represent development at widely different ages. It is obvious that a marked development at a particular age distinguishes it from the others, not in a marked advance in the function as a whole, but rather in what we may call a particular cross section of it, or particular degree of capacity in it. Progress in a function as a whole is uniform and extended over many years.

Similiar uniform and extended progress is represented in the scores of four point scales. A point scale is usually similiar in organization to the Trabue scale in that it includes materials of widespread range in difficulty. An individual's score is made up of the sum of the points which he is able to make in all of the tests which he can pass. These scales, in addition, go one step further in including tests of a variety of sorts of functions. In the first record of progress in a point scale, namely the Yerkes scale, shown in Chart 17, the progress is continuous and uniform up to the age of 12. From that point forward to the age of 20, there is further uniform progress, but at a much slower rate than that below the age of 12. If we reason from this alone, we should conclude that there is a break in mental development at the age of 12. It is quite possible, however, that break in progress is due to the fact that the scale does not furnish as great an opportunity to individuals of the upper degrees of ability as to those in lower ranges. That this supposition is correct is indicated by the fact that progress in the Pressey test, chart 18, and the Chicago Intelligence Test, chart 19, follows a uniform course beyond the age of 12. In the Pressey test this uniform progress is carried as far as age 16, and in the Chicago test to the senior year of the high school. Some allowance should probably be made in the case of the Chicago test for the selection of the brighter pupils in the later years of the high school. This factor, however, is probably not responsible for the great difference found between this test and the Yerkes test.

Additional evidence that progress with age as measured by composite tests follows approximately a straight line within the ages during which growth is continuing is to be found in the norms from the Haggerty point scale, shown in chart 20. The irregularities in the curves are readily explained. The falling off in progress in A at 10 years is doubtless due to the fact that this test is too easy for this grade. Likewise the low score in B at age 8 is due to the difficulty of the test for 8 year old children. The acceleration in B at the age of 15 years is probably due to a selection of the brighter children at this age.

Hypothetical Growth Curves

We may now make an attempt to generalize upon the facts concerning intellectual growth which are represented in the preceeding charts. We may first consider the question as to the general form of the development curve. The fundamental question which arises here is whether development preceeds in general at a uniform rate or whether it is more rapid at one period than at another. Disregarding the question whether there are minor accelerations or retardations in rate, the first question to be considered is whether growth in general is more rapid in the early period of childhood or later on, or whether the progress follows some other course. The widespread view on this matter is represented in the upper curves of chart 21a. This view has been given some support from the analysis of the results of the Binet scale. The particular curves here shown are taken from Woodrow. They represent intellectual growth as being very rapid in the earliest years and becoming progressively slower until it practically ceases at the age of 16. A different conception is represented in chart 21b. According to this conception, progress is comparatively uniform in rate from early childhood to maturity. The limit of progress, furthermore, comes at least somewhat later than the age of 10. Again the same point must be made as was mentioned in the comment on the Yerkes scale. When progress appears to cease at a given age, it is not safe to conclude that this cessation is actual unless we are sure that the tests give an opportunity to superior degrees of ability. There is reason to believe that the Binet tests do not do so, and that therefore the conclusion that progress ceases at 16 is not justified. At what age progress does show marked slowing down we cannot at present say. In all probability it continues with considerable rapidity to the age of 20.

The further discussion of the validity of these two conceptions of age progress is so bound up with the question of individual differences and of overlapping ability of succeeding ages that it can be best taken up after presentation of data upon this matter. We may add, however, a chart which represents a view of mental development which is in harmony with the facts already presented. The figure representing this view is shown on chart 22. On this chart is indicated the relationship between general intellectual progress or composite progress, represented by the straight line, and progress in a series of particular capacities or in narrowly defined measures of general capacities or functions. Such a conception reconciles the superficially contradictory facts shown in the preceeding charts. In some of these, progress seemed to be confined to particular ages while in others progress is spread over a wide range. The view here suggested is that progress in general or composite functions is widely extended, but that this general progress is contributed to by increments of ability in narrow functions or in different applications of a function coming at definite stages of maturity.

A word may be said in explanation of the apparent difference between this picture of the progress curves in particular abilities and the curves taken from separate sentences of the Trabue test. In the former chart the individual curves for more difficult sentences are progressively lower on the chart. In the present chart the curves representing the scores in more difficult tests mount successively higher. The difference is simply one in the mode of representation. In the earlier chart the height of the curves represented the absolute score in the different sentences and the more difficult sentences are therefore lower on the chart. On the present chart the height of the curve represents the degrees of ability indicated by the score, and it is therefore greater in the case of tests of greater difficulty.

RELATION OF AGE PROGRESS TO INDIVIDUAL DIFFERENCES

We have thus far been dealing with average or median progress from age to age or grade to grade. It is well known, of course, that the absolute ability at succeeding ages represented by such median or average curves stands for comparatively few individuals. The range in ability above and below such medians or averages, or the knowledge of the fact that there is such wide range is to so great an extent common property that it is not necessary to dwell upon it. A few illustrations may be given of the extent of this individual difference and we may then pass to certain more particular and less generally known aspects of the matter.

On chart 23 are shown distribution curves in ability in the Trabue scale for selected school grades. The breadth of the distribution is illustrated by the fact that there are pupils in the second grade who get as high a score as pupils in the eighth grade. There is a considerable number of fifth grade pupils who do as well as college graduates. Further illustration may be found on some of the charts from the study of Bickersteth. See, for example, the results of the tapping test, shown on chart 5. The extreme cases are represented by the short lines at the upper and lower parts of the chart. Thus we see that there was a thirteeen year old girl whose tapping rate was below median for the fifth year, and that an eight year old girl made a score equal to a fifteen year old norm. Similar wide ranges appear in the dotting test, shown in chart 6. A further illustration may be taken from results of the picture completion test, chart 10. The dotted lines on this chart include the middle half of the various age groups. We see, for example, that an individual at the upper limit of the middle half at age eight made a score equal to the median at age 10, and equal to the individual at the lower limit of the middle half at the age of 13, five years later. Such facts as this mean, of course, that there is as

Fig. 23. Distribution of scores of five groups in the Sentence Completion Test (Trabue)

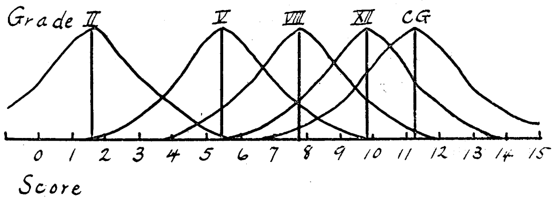
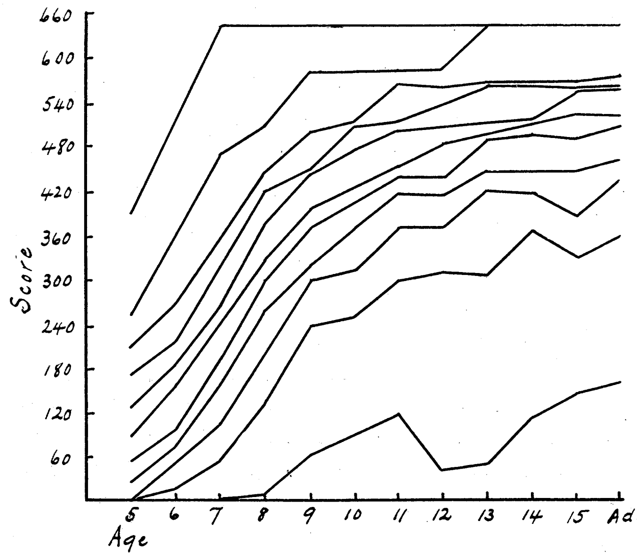


Fig. 24. Age progress curves of ten percentile groups in picture completion test (Pintner)



much overlapping in ability in tests of a general character as we have become familiar with in the case of tests of school subjects.

The question which particularly concerns us here is the bearing of these individual differences upon the form of age progress or, in other words, the relationship between progress from age to age of individuals of different degrees of ability. Does the individual at the lower part of the scale advance by the same stages as the more able individual, or is the form of his progress different? Illustrations which have already been shown suggest that the form of progress in the case of individuals of differing ability is similiar but that their progress is at different levels. This relation is more clearly shown on chart 24. We have here shown ten progress curves, each one representing a given level of ability. These curves are obtained by dividing the individuals of each age group into ten equal sub-groups and finding the scores of each of these smaller groups. It is remarkable that these curves are practically uniform in showing a break in progress at the age of 9, and another somewhat less pronounced break at the age of 11. The test from which this table was made is the picture completion test. It thus appears that whether an individual is of low or high ability he comes to the culmination in his development at practically the same age. This means that insofar as there is a break in the general curve of progress we may expect to find this break at the same point in the lives of different individuals. This is a remarkable and somewhat surprising fact of individual differences. Before adopting it with entire confidence, we should have further evidence of the same sort as that which is here represented, and also a record of the progress of individuals through a succession of years such as will be suggested later, but our present data seem to warrant the conclusion stated above.

The second problem regarding individual differences in their relation to age progress may perhaps be best discussed from the point of view of one of the well known devices in mental testing. This device is a method of expressing the relation between the ability of individual and the ability of the group. In the earlier period of the use of age scales this relationship was expressed in the form of the difference between mental age and chronological age. If the child was able to pass tests equivalent to the ability of the 10 year old child and if he was actually 12 years of age his intelligence was expressed in terms of two years' retardation. It appeared after a time in the experience of those who used the Binet scale that this method did not represent equally the retardation or advancement of children at different ages. Two years' retardation at the age of 6, for example, was found to be more serious than two years' retardation at the age of 12. In fact, it was found empirically that one year's retardation at 6 was about equivalent to two years at 12. The degree of retardation or advancement then came to be expressed in the form of a ratio of mental age to chronological age rather than in the form of the difference between mental and chronological ages.

It is obvious that this practice, and the theoretical basis for it, have bearing upon our conception of intellectual progress. The explanation which has been commonly accepted, and which is perhaps the most natural, is that the rate of progress is continually diminishing. This view is represented on Woodrow's chart already referred to (Number 21a). It may readily be seen how this form of progress would give the basis for the Intelligence Quotient. Compare, for example, the position of the normal individual represented in the middle curve and the moron represented in the next lower curve in relation to one another at the ages of 6 and 12. The six year old moron is practically at the same level of ability as the four year old normal child. The twelve year old moron, on the other hand, is at practically the same level as the eight year old normal. Thus the ratio between the mental ages of the individuals remains constant, which is what we should expect.

There is another condition, however, which would give the same constant intelligence quotient, and which would permit the hypothesis that the rate of progress is uniform rather than decreasing. That condition is illustrated in chart 21b. This assumes that the progress lines of various individuals of differing ability are straight and that they diverge in the upper ages. The consequence of this would be that the range of distribution of the individuals in successive age groups would become greater. Take again, for illustration, the comparison between normal and low grade individuals at ages of 6 and 12. The low grade individual at age 6 is equivalent in ability to the normal four year old, and the low grade individual at age 12 is equivalent to the normal eight year old. The ratio remains constant.

We thus see that the problem of the intelligence quotient involves two conditions rather than one. It depends upon both the form of progress and the spread of distribution at successive ages.

In support of the view that the rate of progress is a diminishing one, the fact that there is more overlapping in the scores of adjacent ages in the upper age levels than in the lower ones is sometimes cited. Thus, if we compare the percentage of the 5 and 6 year old pupils who pass the six year old tests in the Stanford Revision of the Binet scale we find that the average difference is 23 per cent. If, again, we compare the standing of the 10 and 12 year old children in the 12 year old tests, the difference is nearly the same, namely 26 per cent. This means that in the tests that are used in the Binet scale there is more overlapping between successive age groups in later than in earlier ages. It is clear that this increase in overlapping in the latter ages is the justification for the use of the Intelligence Quotient with the Binet Scale.

The cause of this difference in the overlapping at different ages has been assumed, as has already been said, to be due to diminution in the rate of mental development. It might equally be due to the increase in the range of distribution of the individuals of the higher ages. Our next problem then is to determine what the actual cause is, and whether this cause pertains to all tests, so as to determine whether the method of expressing intelligence by the Intelligence Quotient is universally appropriate.

With reference to the question whether age progress follows a straight line or a negatively accelerated curve, numerous progress curves which we have before us give some evidence. The general fact is that narrowly specialized functions give a curve whose rise is slower in the later ages than at some earlier age or succession of ages. On the other hand, a test of a more composite nature, which offers the opportunity of a wide range of scores, gives something nearly approaching a straight line progress. We cannot determine what the type of progress is in the Binet scale since it is not scored in absolute units, but in terms of mental age. The whole scale is standardized in age terms and therefore cannot be used directly to indicate the type of age progress. This is the reason why resort has been had to the indirect method already mentioned. The burden of evidence seems to be that a composite test like that of the Binet scale ordinarily gives straight line progress provided a sufficiently wide range of scores were possible.

We may then examine the other possible explanation of the fact that the Intelligence Quotient is valid when applied to the Binet Scale, assuming for the moment that it should give a straight line progress if scored in absolute terms. The other possible hypothesis is that increased overlapping in the upper ages is due to an increase in the range of distribution of the individuals. We may examine a number of cases in which the range of distribution has been calculated. Reference may be made to charts No. 5, 6, 8, 9, 10, 15, 19, 24. In this fairly comprehensive group of tests there does not appear to be any general tendency to increase in the range of distribution of scores in the upper ages. It seems legitimate, therefore, to eliminate this as a cause of increased overlapping in general, and in the Binet scale in particular.

The conclusion to which we are forced, if these inferences are correct, is that the Binet scale is an exception to the majority of composite tests, in that it actually does give decreasing of rate advancement in the later years. This inference is strengthened by the fact that the Yerkes scale, which applies a method of absolute scoring to some of the Binet materials, gives a decreasing rate of advance beyond the age of 12. That such a form of development, however, is to be regarded as characteristic of intellectual life in general is not to be concluded. It is due, in this case, as evidence seems to warrant, to limitations of the Binet scale in the upper ranges of difficulty.

This conclusion has bearing upon the tendency which is being manifested to apply the same method of reckoning intelligence by means of the Intelligence Quotient to scales in general, since there seems good warrant for the belief that neither a diminishing rate of advancement nor increased spread of distribution is characteristic of the scales which give sufficient range of difficulty at the upper levels, up to the period of middle adolescence at least. It is very doubtful whether the Intelligence Quotient is to be generally applied. It seems likely that it might turn out that the earlier difference between chronological and mental age may be more generally applicable.

A few supplementary topics may be discussed very briefly.

Correspondence Between Physical and Mental Development

A survey of the curves of growth in special and general functions seem to give little ground for the theory that widespread and general crises or stages in mental growth correspond to particular stages or transitions in physical development. The two prominent turning points in physical growth are second dentition, occuring at about eight years, and adolescence, beginning, roughly, at about twelve years. Particular functions show rapid growth at certain ages, and these stages in growth come at very similar ages in different children; but cases can be found of rapid development occuring at practically any age. It is simply necessary to choose an appropriate mental process, or a test of appropriate difficulty, in order to find rapid development at any point. Composite or general curves show very little tendency to break at any particular age. If there is any such tendency it is comparatively slight, and is more likely to come in the neighborhood of the year twelve than at any other time. This may be interpreted, probably, as due to some general disturbance resulting from physiological and instinctive changes rather than to any fundamental and deep-seated effect of growth changes upon intellectual capacity.

These conclusions are, of course, limited to intellectual capacity, which is the function measured by these tests. No implication at all is intended with reference to emotional attitudes, instincts or interests. This may very likely be much more closely related to stages in physical growth than are intellectual capacities.

Practical Application of the Above Conclusions

It is clear, in the first place, that the child passes through fairly clearly marked stages when his progress is measured by his achievement in narrowly defined capacities, or by tasks of definite degrees of difficulty which are examples of general functions. Thus the child's ability in color discrimination or pitch discrimination, in oral reading or adding or subtracting, and perhaps as well in certain aspects of the content subjects—history, geography, science not yet defined—culminates at specific ages. Training should obviously be adapted to these periods of culmination.

Just how this adaptation should be worked out is not quite clear. Take pitch discrimination as an example. Should training be emphasized during the period when the function is developing rapidly or should it await the time when the development of the function culminates? It is quite possible that this question must be answered differently for functions which develop relatively spontaneously, such as sensory discrimination, and those in which specific school training is a much larger factor, such as facility in the number operations. We do not know without more scientific experimentation on this point, how far down the culmination in particular school abilities may be pushed, nor do we know what the relative length of the period of training would be at different ages. In the case of the school subjects the facts of age progress are complicated by the training factor.

The results of mental tests throw some light on the urgent problem of grouping pupils in classes. If pupils are grouped according to their absolute ability children of different ages and of different stages in the development of their mental functions will be put together. This is well shown in chart 21. In presenting this chart Pintner suggests that such a grouping may be desirable. It is very questionable, however, whether it is so. Such a grouping brings together pupils who are unlike, not only in their general social attitudes and instinctive development, but also children who are at different stages in the development of particular intellectual functions. The traditional method of grouping which brings together children of about the same age, makes it necessary, on the other hand, to handle in the same class pupils of vastly different absolute ability. The difficulties of this procedure are evident to every teacher. The only satisfactory solution is to group together pupils who are alike both in stage of advancement and in absolute ability. When the numbers are too small to allow the number of groups which this arrangement involves it is necessary to meet the situation by individualizing instruction as much as possible.

Do the facts indicate that there are clearly marked crises in general intellectual development, or that there are ages at which a culmination in a sufficiently large number of particular functions occurs simultaneously, to warrant, on the basis of intellectual development alone, an administrative division of the school into units? The writer does not believe that they do. It is quite possible that such a division is justified on other grounds. When the pupils arrive at a given stage of maturity, they may be prepared for a different form of organization, such as more extensive departmentalization, or more specialization, simply because they have reached such a level of maturity as fits them for an objective task of a given difficulty or complexity. But this would not imply either having arrived at such a level suddenly or ceasing to progress beyond it. Furthermore the necessity for a new type of organization, such as is represented in the Junior High School, may arise from the acquisition of new interests and social attitudes, quite apart from intellectual ability. The introduction of a new form of organization, then, is dictated, in all probability, not so much by clearly marked stages in general intellectual development, as by the broadening out and specialization which follows the pupil's mastery of the common fundamentals of his education and by the necessity of a different type of management which results from the pupil's new social attitude.